Note on Vertical Test Results of Cavity TE1AES004 – 2nd Test Cycle

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Background

Cavity TE1AES004 is a single cell cavity manufactured by AES Corporation. It was initially processed (BCP) and tested at Cornell University, where it reached a maximum gradient of 25MV/m, limited by field emission and low Q_0 (1.4 x10^9). It was then shipped to Fermilab/ANL for EP processing, HPR, assembly, and test. Results from the first test cycle (9/30/08 – 10/7/08) showed the cavity reached a maximum gradient of 33.1 MV/m, and was limited by Q-drop and field emission. The onset of field emission was 23 MV/m, with a maximum x-ray flux at maximum gradient of 3.3 mR/hr.

After this test, the cavity was warmed up, baked at 120C for 48 hrs, and re-tested. During this process, a leak developed in the cavity vacuum line, which essentially led to the cavity being vented to room air. The line was repaired and the cavity pumped back down, however subsequent testing indicated that the cavity had been contaminated by the vacuum system breach and exhibited strong field emission. Field emission began at about 16MV/m (to be compared with 23MV/m from the pre-baking test), again leading to a strong Q-drop. This time, the maximum gradient reached was only 23.8MV/m with a Q_0 of 1.4 x10^9. The radiation at maximum gradient had increased to 8.4mR/hr - an almost 3-fold increase, but at ~70% of the previous field.

As a result of this test, it was decided to send the cavity to the A0 cavity processing facility, where it was disassembled, re-rinsed (HPR only), assembled, evacuated, and leak checked. The cavity was then transported to IB1 and mounted to the test stand. The cavity was connected to the pumping system using the standard clean-room procedures and protocols as modified for use in IB1. Once connected, the cavity isolation valve was opened slowly, yielding a less than 1 decade transient increase in vacuum system pressure level, maintaining laminar flow regime conditions. The cavity was instrumented with the single-cell diode thermometry system, and also 8 photodiodes for x-ray detection.

Tests & Results

The VTS Dewar was cooled down and filled at 4.4K. The bath was then pumped to 2K. Some low-field Q_0 vs T data were taken, primarily just above and below the λ point, until a temperature of 2K was reached. Once the bath reached 2K, a Q_0 vs E run was performed.

During the initial Q_0 vs E run at 2K (shown in Figure 1.) several instances of field emission were observed at low field levels (between 13 -18 MV/m). In all cases the FE processed away, the Q_0 recovered, and gradient could then be increased. A soft multipacting barrier was encountered at 19.5-20.0 MV/m, and was breached through CW processing over a short period of time. Field emission continued as gradient was increased, leading to a marked Q-drop. The cavity reached a maximum gradient of 33.3 MV/m with a Q_0 there of 1.54 x 10^9. At maximum gradient the maximum x-ray flux was 11.9 mR/hr. The low field Q_0 was 2.1 x 10^{10}. A final Q_0 vs E run was performed (shown in Fiugre2.), which showed that the MP barrier was no longer active (surface

had been sufficiently processed to yield a SEY < 1) and that the field-emission sites active at low field had also been processed away.

The cavity's ultimate performance, as shown in Figure 2, is remarkably similar to its performance when first tested after undergoing EP at ANL. This is evident in Figure 3, which compares the results from both test cycles. One might have expected that a cavity whose performance was dominated and limited by field emission would have a different behaviour after a subsequent HPR and assembly. This is indeed typically what is observed and is the rationale for re-rinsing (using HPR) cavities that are poor performers with regard to FE. This technique works when the FE is due to contaminants that are either not strongly bound to the cavity surface, and/or not widely (globally) distributed across the cavity surface. This does not appear to be the case with cavity TE1AES004 – the FE may be due to a larger contaminant (or contaminants) that are stuck to the cavity surface, perhaps as a result of initial RF activity, and so are immune to removal by HPR, or it is due perhaps to a widespread chemical or physical "residue" that is likewise strongly attached the cavity surface, and perhaps not uniformly remedied with HPR. Both of these scenarios are consistent with the observed behaviour. The slightly earlier FE onset, and greater maximum radiation intensity (for the same maximum gradient) in the later (12/8/08) test would indicate that the subsequent HPR and assembly activity at A0 has somehow created a marginally more favorable environment for this resilient form of FE, in addition to also introducing low-field FE sites to the cavity surface. It is not believed that the cavity FE behaviour is due to potential contamination from the test stand pumping system, as this would be more likely characterized by a random performance degradation over test cycles.

During assorted Q_0 vs E runs, the diode thermometry and photodiode systems were performing scans. Results and analysis from these data will be provided separately.

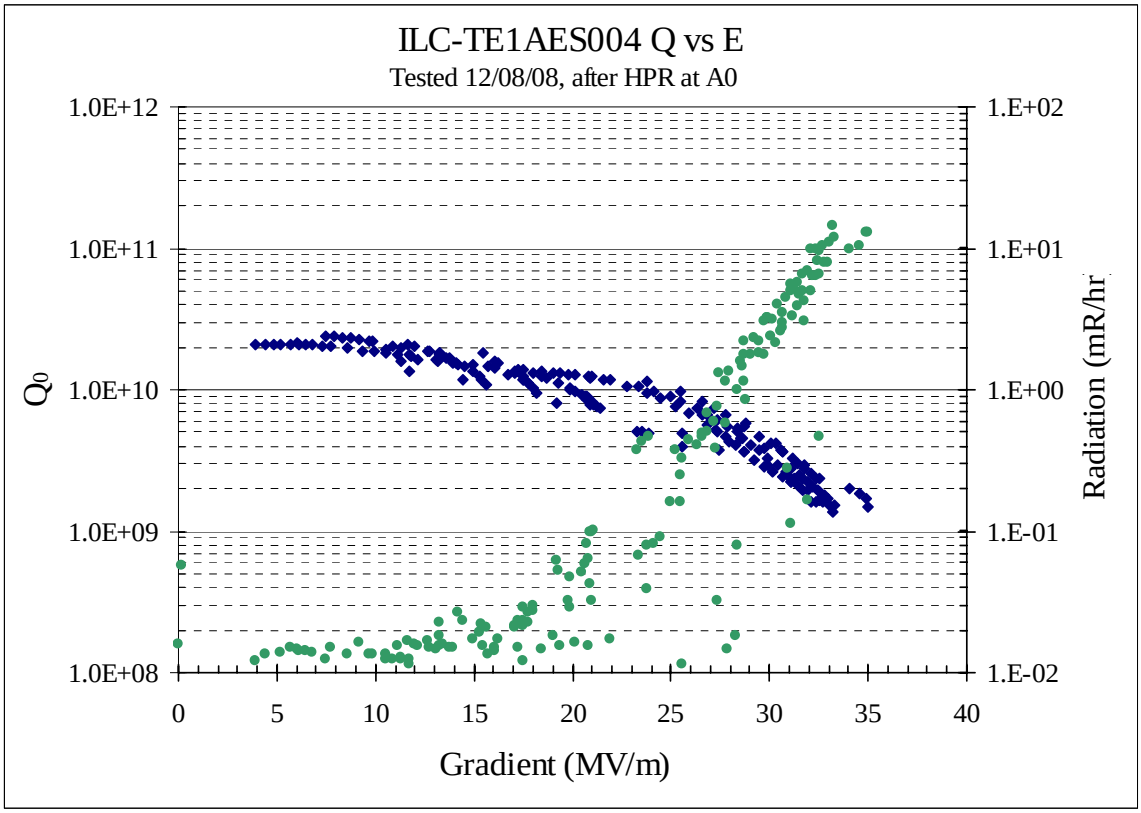

Figure 1.) Initial Q_0 vs E run at 2K

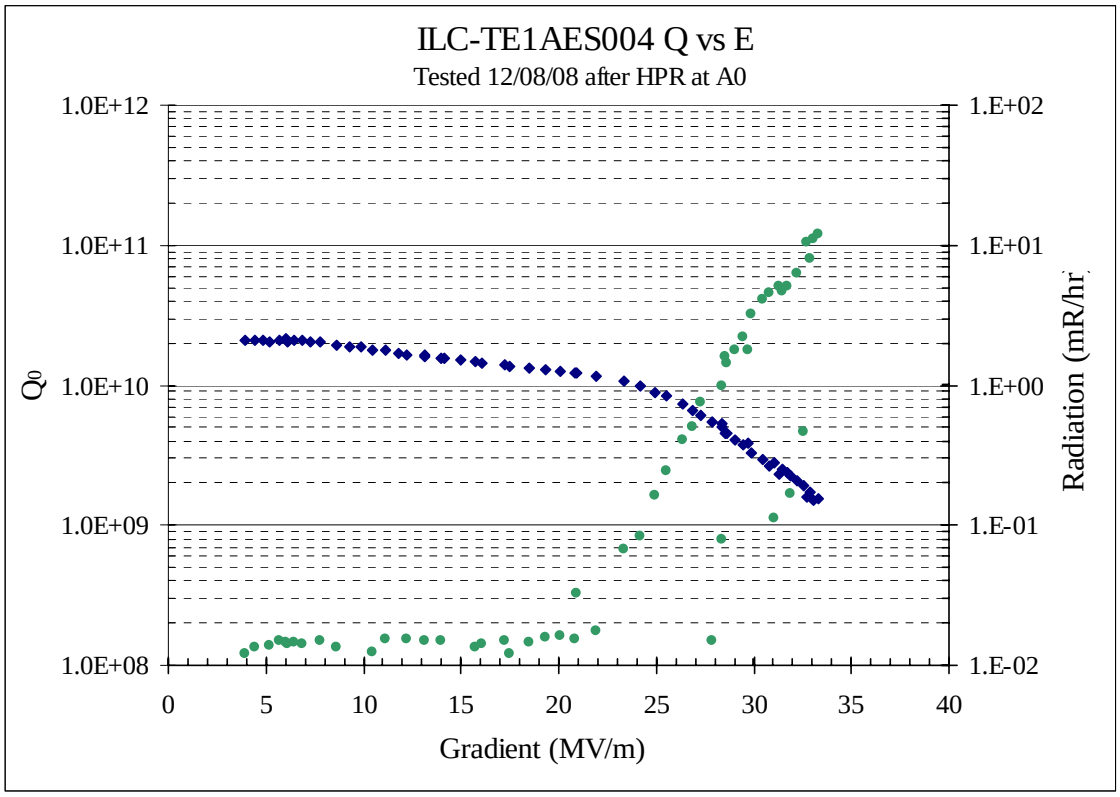

Figure 2.) Final Q_0 vs E run at 2K after low-field FE and MP have been processed away.

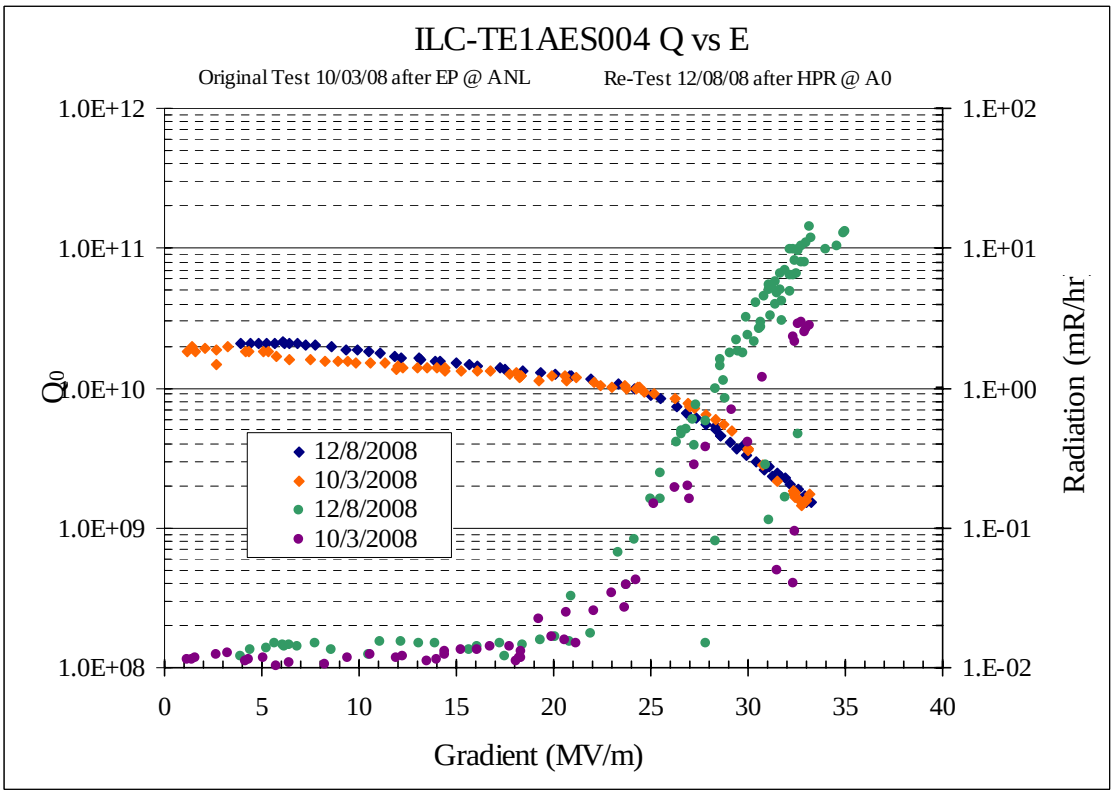

Figure 3.) Comparison of Q_0 vs E behaviour of cavity TE1AES004 after initial EP, HPR and assembly at ANL, and after subsequent HP at A0.